

plant*. The area immediately surrounding the doors is covered with the same leafy flakes; so that, when closed, the doors become almost invisible. The nest itself consists, not of an elongate silk-lined tube, as is usual in this group, but simply of a shallow excavation on the surface of the tree-trunk.

EXPLANATION OF PLATE III. A.

Fig. 1. *Ecophlaeus cincitipes*, g. et sp. n. Dorsal view, nat. size.

Fig. 2. Nest, showing the two doors.

VII.—*Suggested Terms in Crinoid Morphology.*

By F. A. BATHER, M.A.

IT is to be feared that the title of this paper will bring a smile to the lips of those who think, not without some show of reason, that students of Crinoid morphology spend more time in quarrelling as to what terms they are to use than in finding out fresh facts that should warrant any departure from the language of the text-books. It is not long since there appeared in this Magazine several notes on the Anatomical Nomenclature of Echinoderms from the pen of the leader whose loss we so deeply lament—P. H. Carpenter †. The object of that paper, however, was to give greater *precision* to the nomenclature of Echinoderm morphology rather than to propose any great novelty. The object of the present paper is different: it is to propose certain changes in the terminology of the various parts of a Crinoid, partly because it is hoped that these changes will facilitate the drawing up of descriptions and give greater clearness to our ideas, partly because it is believed that they are necessitated by recent advances in Crinoid morphology.

Every scientific paper should be its own apology; at the same time some reply may be offered to two different classes of objectors.

Those who have an innate objection to all change may be answered by the following quotations from a recent article by Prof. T. Jeffery Parker ‡:—"I think it may be taken as

* I am indebted to my colleagues of the Botanical Department of the Natural-History Museum for this information respecting the nature of the substance of which these doors are composed.

† Ann. & Mag. Nat. Hist. ser. 6, vol. vi. pp. 1-23, July 1890.

‡ "Suggestions for securing greater Uniformity of Nomenclature in Biology," 'Nature,' vol. xlv. p. 68, Nov. 19, 1891.

axiomatic that whenever the bounds of knowledge are extended, either by the investigation of new problems or by the re-examination of old ones with the aid of improved methods and extended views, an elaboration of nomenclature is inevitable. Indeed, the introduction of an extended terminology, either because of the discovery of new facts or of the more accurate grouping of old ones, is a distinct gain; it emphasizes an actual advance in knowledge." "In morphological nomenclature suitability is of far more importance than priority, and the most respectable and time-honoured terminology should never be allowed to stand in the way of one by which homologies, mutual relations, &c., are adequately expressed."

To those who deem it hardly fitting that one who has so recently entered on the field of Echinoderm morphology should be already running atilt at terms that have long held the ground, no other reply is needed than that the proposed terms were arrived at after considerable discussion with Dr. P. H. Carpenter, and that nearly all received his definite approval. Without his encouragement this paper would not have been written, and it has only been the sudden removal of his kindly help that has prevented its earlier completion.

Super-radials and Infer-radials.

Many of the Monocyclic genera of Crinoidea Inadunata are remarkable for the transverse bisection of some or all of the radial plates of the dorsal cup. To these radially situated plates themselves the term "Radials" is restricted, but it is convenient to have some short term to express their upper and lower halves. For these therefore I propose the terms "Super-radials" and "Infer-radials," which may be represented symbolically by R^s and R^i . Instead of saying "the lower half of the left anterior radial," we shall now be able to say "the left anterior inferradial" (l. ant. R^i). The plate for which the term Radial (R') has been adopted is of course the right posterior inferradial (r. post. R^i); while the right posterior radial, being the upper half of the same plate, is morphologically the right posterior superradial (r. post. R^s).

Arm-ossicles.

In July 1890 the following terminology was proposed for the various series of arm-ossicles by P. H. Carpenter * :—

* *Op. cit.* p. 11.

Brachials = all arm-ossicles, or, in other words, all ossicles situated in the direction of the rays, distal to the radial (*s. str.*) and belonging to the abactinal system.

Costals = the first order of brachials, *i. e.* all brachials from the radial up to and including the first axillary.

Distichals = the second order of brachials.

Palmars = the third order of brachials.

First Postpalmars = the fourth order of brachials.

Second Postpalmars = the fifth order of brachials; and so on.

Free Brachials = all brachials after the last axillary, whichever that axillary may be.

Through the kindness of Dr. Carpenter I had already been able to put forward the above terminology * and to announce that it would be used in my papers on British Fossil Crinoids. Wachsmuth and Springer had also privately expressed their intention of accepting it. The latter authors, however, have already found it necessary to modify it slightly †. "To the most of this terminology," they say, "we entirely agreed, but in some particulars it does not quite meet the requirement in dealing with the greater complexity and variety of construction found in the Palæozoic forms." Instead of applying the term *Free Brachials* to brachials after the last axillary only, they use it in a different and extended sense, applying it to all brachials that are free from the calyx, as are all the arm-ossicles in the Inadunata. The term is thus opposed to *Fixed Brachials*, by which is meant those arm-ossicles incorporated in the calyx, such as are often found in the Camerata.

In the same place Wachsmuth and Springer have supplemented the above terminology, as follows:—

"*Interradials*, all plates interradially disposed in the calyx.

"*Interbrachials*, a general term for all plates between the rays above the radials.

"*Interdistichals*, the plates between the first divisions of the ray.

"*Interpalmars*, those between the second divisions of the ray.

"*Interambulacrals*, the plates between the ambulacra."

In applying to Palæozoic Crinoids the terminology to which I stood committed, I soon stumbled on certain difficulties. This was especially the case in the attempt to work out and

* "Brit. Foss. Crin., II.," Ann. & Mag. Nat. Hist. (6) vol. v. p. 313, April 1890.

† "The Perisomic Plates of the Crinoids," Proc. Acad. Nat. Sci. Philadelphia, vol. for 1890, p. 374: Feb. 1891.

to formulate the laws of arm-branching in the various families or genera. The difficulties are of two kinds, subjective and objective. We will take them in that order.

The subjective difficulties are due chiefly to the cumbrous, illogical, and, for the most part, meaningless nature of the terms adopted. This is not a censure of any one in particular, for no one man could ever have invented such a disconnected lot of names for similar and connected objects. The terminology has grown up bit by bit, unsubjected to the stern laws of *natural* selection. It is by no means easy for the student, or even for the describer of new species, to carry all these names in his head. It is on the face of it absurd to begin a fresh series of numbers at the postpalmar, as though there were some morphological change; moreover, the interpretation to the mind of such a phrase as "the second postpalmar" involves an arithmetical calculation before one realizes that the ossicles alluded to are brachials of the fifth order. Then, in speaking of a particular ossicle, one can hardly say "the second third postpalmar," so one is obliged to indulge in some such cumbrous circumlocution as "the second ossicle in the third postpalmar series." The symbols too that are employed in specific formulæ—*c*, *d*, *p*, *p'*, *p*ⁱⁱ, *b*, &c.—hardly convey their meaning at a glance, while they certainly do not lend themselves to the expression of statements referring to more than one order of brachials at a time. It is of course possible that these difficulties are not obvious to highly trained intellects, and it is true that they hardly present themselves in the study of most recent Crinoids.

There is, however, a more serious objection, at least to one of the terms. It was J. S. Miller who invented the now resuscitated term "costals," and it is true that he used it to denote the second radials, where he did not call them arm-plates. But, as can be seen from the table that was given by Carpenter (*op. cit.* p. 16), he also applied the term to the first radials, the basals, and the infrabasals. It would no doubt have been legitimate to restrict the term to one or other of the plates to which it was applied by Miller; but unfortunately this had already been done. As Carpenter himself pointed out, Prof. Lovén has "proposed to specialize this name as denoting the primary interradial plates of the Echinoderm apical system, *i. e.* the genitals of Urchins and the basals of Crinoids." It may be true that Prof. Lovén's proposal "has not been generally accepted by Echinologists;" at the same time there are others who have applied the term "costals" to interradially disposed plates, notably Prof. James Hall, who has thus denoted the basals of various species in the 'Palæon-

tology of New York,' vol. i. (1848). It seems to me therefore that the use of the term "costals" in the sense now proposed cannot be justified, and I regret that I ever agreed to use it.

The objective difficulties in the way of the proposed terminology are due to the more correct views that are now held with regard to the homologies of pinnules. As was fully explained in the section on the Arms in "British Fossil Crinoids," Part II. (p. 374), pinnules are nothing more than armlets that have become small, ceased to branch, and are regularly placed on alternate sides of successive ossicles. An armlet itself is merely one branch of a dichotomous arm reduced in size. Consequently, from a morphological standpoint, a pinnule, however small, is the homologue of a whole dichotom (as we may conveniently call such a branch), while the ossicle that supports a pinnule is simply an axillary, and this without going beyond the strict conception of that term as recently laid down by Carpenter (*op. cit.* p. 19).

If now we turn to such a genus as *Botryocrinus*, and compare two of its species, such as *B. ramosus* and *B. decadactylus**, and if we name the successive orders of brachials after the methods hitherto followed, we shall come to these conclusions—that

in *B. ramosus*

in *B. decadactylus*

| | |
|----------------------------|---|
| the costals are homologous | with the costals; |
| the distichals | „ with the first two distichals; |
| the distichal axillary | „ with the second distichal; |
| the palmars | „ with the third distichal and the first pinnule, or, if this pinnule is branched, with the proximal portion thereof; |
| the first postpalmars | „ with the fourth distichal, the second pinnule, and the branches of the first pinnule if it be branched; |
| the second postpalmars | „ with the fifth distichal and third pinnule; |

and so on. Which conclusions appear a sufficient *reductio ad absurdum* of our present methods. Those methods were only legitimate so long as pinnules were considered to be structures distinct from arm-branches and present or not according to some unrecognized or, at the best, empirical system.

From the foregoing review of the circumstances it appears that a terminology is required that shall fulfil the following conditions. Homologous parts must receive the same name. Parts serially homologous must receive names of a similar nature. When specialization and differentiation have taken

* Brit. Foss. Crin., V., Ann. & Mag. Nat. Hist. ser. 6, vol. vii. pp. 394 and 398.

place, there should be some means of expressing the facts in a simple manner. *Ceteris paribus*, the names employed should at once convey to the mind the idea denoted by them, and should involve as little change as possible from terms that previous naturalists have been accustomed to use. It will also be advantageous if the system of terminology is capable of extension both along its own lines and to parallel structures, and if it can be readily expressed by intelligible symbols such as can be utilized in formulæ.

It is believed that the system about to be detailed does fulfil these conditions as far as possible, and since not one of those conditions has been adequately fulfilled by previous systems, it may claim to be their superior in these respects at least.

Examination of the Carpenter-Wachsmuth system brings to light one term, and one only, that has a meaning, viz. the Müllerian term "distichals." At first, therefore, it seemed natural to suggest that the successive orders of brachials should be designated *monostichals*, *distichals*, *tetrastichals*, *octastichals*, and so on. This plan would inform us how many corresponding branches there ought to be at the level alluded to; but as this number would only be complete in a regularly dichotomous arm, such information would in many cases be merely misleading. Another objection to the system, so far as Palæozoic forms were concerned, lay in the words "so on." For instance, such a term as "eikosinoctokaihekato-stichals" would not commend itself to the gentlemen who are so anxious to eliminate Greek from the education of a man of science, and even a mathematician might take some time in discovering that "128 stichals" signified the fifth post-palmars.

This suggestion may therefore be set aside for the present.

Instead, recourse may be had to the Latin language and to the method of simple enumeration. The term "Brachialia" may be simply combined with the Latin ordinal numbers. Since, however, this plan would produce rather lengthy words, even in their anglicized form, it seems advisable to shorten "brachialia" to "brachs." The terms thus formed are easily represented symbolically by the respective Roman numerals preceding "Br," e. g. IV Br., while the actual ossicle alluded to may be represented by an arabic numeral placed below the line after "Br," e. g. IV Br₂. When it is desired to indicate the fact that the ossicle alluded to is an axillary, the suffix "axil" may be combined with the appropriate numeral; while in the symbols "ax" will supplant "Br" (see Table, p. 57).

TABLE OF PROPOSED TERMS AND SIGNS.

| FOR SIMPLE ARMS. | TERMS IN USE. | FOR COMPOUND ARMS. | OTHER RADIAL PLATES. |
|---|--|--|---|
| Primibrachs I Br | Costals <i>c</i> | Monostichals (First Order) 1 St | Infer-radial R ⁱ |
| First primibrach I Br ₁ | First costal | First monostichal 1 St ₁ | Super-radial R ^s |
| Second primibrach I Br ₂ | Second costal | Second monostichal 1 St ₂ | Radial R' |
| Primaxil I ax | Axillary costal | Monaxil (First Mainaxil) 1 AX | Inter-secondibrachs i II Br |
| Secondibrachs II Br | Distichals <i>d</i> | Distichals (Second Order) 2 St | Inter-tertiobrachs i III Br |
| Secundaxil II ax | Axillary distichal | Distaxil (Second Mainaxil) 2 AX | Primambulacs I Amb |
| Tertiobrachs III Br | Palmar <i>p</i> | Tetrastichals (Third Order) 4 St | Inter-primambulacs i I Amb |
| Tertiaxil III ax | Axillary palmar | Tetraxil (Third Mainaxil) 3 AX | Secundambulacs II Amb |
| Quartibrachs IV Br | First post-palmar <i>pp</i> | Octastichals (Fourth Order) 8 St | &c. |
| Quartaxil IV ax | Axillary first post-palmar | Octaxil (Fourth Mainaxil) 4 AX | |
| Quintibrachs V Br | Second post-palmar <i>ppii</i> | (Fifth Order) 16 St | |
| Sextibrachs VI Br | Third post-palmar <i>ppiii</i> | (Sixth Order) 32 St | |
| Septimibrachs VII Br | Fourth post-palmar <i>ppiv</i> | | |
| Octavibrachs VIII Br | Fifth post-palmar <i>ppv</i> | | |
| Nonibrachs IX Br | Sixth post-palmar <i>ppvi</i> | | |
| Decimibrachs X Br | Seventh post-palmar <i>ppvii</i> | | |
| finials <i>f</i> | Free brachials (P. H. C.) <i>b</i> | | |
| | | [Higher Greek terms are rarely needed.] | |
| | | [These are not needed.] | |
| | | Finials <i>F</i> | |
| | | | FIXED BRACHIALS Br |
| | | | <i>e. g.</i> I-III Br ₂ |
| | | | CIRICALS C |
| | | | RADICALS √ |
| | | | INTERRADIAL PLATES IR |
| | | | Interbrachials <i>ibr</i> |
| | | | First interbrachials <i>ibr₁</i> |
| | | | &c. |
| | | | Interambulacral <i>iamb</i> |
| | | | Deltoids Δ |
| | | | Anal <i>x</i> <i>x</i> |
| | | | "Third anal" <i>rt</i> |
| | | | Corresponding plate on left <i>lt</i> |

N.B.—A sign between brackets, thus (II Br₁), denotes *variability*; while II Br₂ denotes *ignorance of number*. II Br₄₊ indicates that 4 are known, but that more existed, i. e. *incompleteness*.

This system has the advantage of at once conveying to the mind, in the simplest possible manner, the desired ideas. It is obviously capable of indefinite extension; but, since very few arms branch as many as twelve times, it does not involve words of any great length. It is true that "primibrach" is longer than "costals;" but then "the fourth sextibrach" is far shorter than "the fourth brachial of the third post-palmar series" or even than "the fourth ossicle after the fifth axillary," which latter is a periphrasis proposed to me by Mr. Wachsmuth. Besides, the system is merely a more convenient rendering of terms that have been, and are still, employed by authors of repute, including Wachsmuth and Springer. In a letter dated August 5th, 1891, Mr. Wachsmuth writes: "The terminology of the brachials which you propose is almost the same which I proposed to Carpenter when we discussed the question two years ago, with the exception that I called the costals 'primary brachials,' the distichals 'secondary brachials.' At first we thought these terms were excellent, but, using them in some of our descriptions, we found them extremely cumbersome, and this induced us to accept Carpenter's terms." He adds, however, "we occasionally use primary and secondary brachials in place of costals and distichals as a change." The alteration involved in adopting the proposed system is therefore of the smallest possible kind, while the terms have all the 'excellence' without the 'cumbrousness' of those still used occasionally by Wachsmuth and Springer.

A still greater advantage of the new system is that it can be extended to all parallel structures. The general term at present applied to the covering-plates of the ventral grooves is "ambulacralia." This word may be conveniently shortened in composition, and the various series denoted as "primambulacra" &c. A similar nomenclature can be applied to cirrus-ossicles or "cirrals," and to root-ossicles or "radicals," in cases where these branch.

The supplementary plates that occur in some *Camerata* between the secundibrachs and tertiobrachs of a single ray have been called "Interdistichals" and "Interpalmars." The change to "Intersecundibrachs" and "Intertertiobrachs" is hardly euphonious; but there is rarely occasion to use these terms. The corresponding plates of the ventral surface should of course be known as "Intersecundambulacra" and "Intertambulacra:" these plates have hitherto had no distinctive names, and some may think that it was better so.

As yet we have only considered the proposed system in its application to simple or non-pinnulate arms, when those are

free from the radials upward. Let us now consider it with reference to pinnulate arms.

First in cases where these are free. Strictly speaking the first ossicle that bears a pinnule is homologous with the primaxil, and the next one bearing a pinnule with the secundaxil. But however philosophical this may be, it is clear that, after all, practical people do need some name that shall include all the pinnuliferous ossicles of any one series or order. In supplying this want we may adopt one of two courses. Either we may retain the present system with its illogical names, or we may evolve a new system that shall answer the requirements of a morphological terminology as laid down on p. 55. There can be little doubt that the former course will recommend itself to those who have to deal only with recent Crinoids, the vast majority of which belong to the genera *Antedon* and *Actinometra* (*Comaster*), for the species of which genera formulæ have been constructed by F. J. Bell* and P. H. Carpenter†. When, however, we consider fossil pinnulate genera, especially in the Camerata, the second course would appear to be accompanied by fewer difficulties.

For descriptive purposes, then, I would propose a terminology congruous with the Müllerian term "distichals." The objections to this that were stated above do not apply in the case of pinnulate genera, for in them the branching is almost always quite regular and does not take place so many times: except in formulæ, it would rarely be necessary to speak of any brachials higher than the octastichals. As a rule the monostichals correspond to the primibrachs, and there is no reason why the latter term should not be employed. In *Metacrinus* and *Calamocrinus*, however, pinnules are borne by the brachials of the first order. In that case the two terms do not apply to the same things, and the word "monostichals" must be adopted.

In cases where some of the proximal series of brachials enter into the dorsal cup, these may be called by Wachsmuth and Springer's term "Fixed brachials" or "*brachialia fixa*;" while those outside the limits of the cup will be "Free brachials" or "*brachialia libera*." In formulæ and symbols it would have been natural to have expressed the difference between the two by enclosing the fixed brachials in brackets. Brackets, however, have already been employed by Bell and Carpenter, with far less obvious significance, to denote uncer-

* "An attempt to apply a method of Formulation to the species of the Comatulidæ &c.," Proc. Zool. Soc. Lond. 1882, pp. 530-536.

† 'Challenger' Zoology, vol. xxvi. part lx., Report on the Comatulæ, pp. 43 et seq., 1888.

tainty of occurrence; instead, therefore, it will be necessary to use a brace, or even a simple rule, placed above the symbols of those brachials that are included in the cup. Thus $\overline{\text{II Br}}$ would indicate the secundibrachs, while conveying the additional information that they were fixed.

In cases where some only of the free brachial series bear pinnules, it would be well to apply the Latin terminology to those brachials without pinnules, whether free or fixed, and the Greek to those with pinnules. Thus, $\overline{\text{I-II Br. III Br. 8 St}}$, indicates that both primibrachs and secundibrachs are fixed, that the tertiobrachs are free but do not bear pinnules, that the next series of arm-ossicles are free and bear pinnules, and that there are eight free arms to a ray. The best way of representing the number of ossicles in each series will be discussed presently.

If the term "Free brachials" be used in the sense here ascribed to it, it can no longer be applied to the distal unbranched ends of the arms. If it is really necessary to have a special term for these ossicles, the word "finials" may be appropriately conveyed from architectural terminology. The word "terminals" already has its special use in Echinoderm morphology. The symbol for finials may be *f* when they do not bear pinnules, and *F* when they do. In all formulæ the last or right-hand term of the brachial series should always be understood as applying to the finials, so that there will rarely be any need to use the special symbol *f*. For the same reason it seems unnecessary to have different terms to express pinnulate and non-pinnulate finials, although, strictly speaking, non-pinnulate finials are homologous only with the last pinnule borne by the finials of a pinnulate arm.

Another difficulty arises with regard to the word "axillary." As has been pointed out, each pinnuliferous brachial is morphologically an axillary. Consequently, if the morphological terminology be followed, supposing that the ossicle on which a pinnulate arm first branches be the primaxil, then the two ossicles that this supports are the secundaxils; and if there are six distichals the sixth will be the septimaxil. The septimaxil then, in this case, is the same as the distichal axillary. It will therefore be convenient to distinguish those axillaries on which a pinnulate arm itself branches as "mainaxils;" and instead of alluding to them individually as "monostichal axillary," "distichal axillary," and so on, they may be spoken of as "first mainaxil," "second mainaxil," and so on; or they might possibly be called "monaxil," "distaxil," "tetraxil," "octaxil," &c. In the symbols, the mainaxils may be distinguished from the simple axillaries by-

being represented by "Ax" instead of "ax," and by the use of Arabic instead of Roman numerals.

We are now in a position to express in the formulæ the number of brachials in any series. To say that the Quartaxil is the fifth ossicle of its series is obviously the same thing as saying that there are five quartibrachs; while to say that the third mainaxil (or Tetraxil) is the fourth ossicle of its series is obviously the same thing as saying that there are four tetrastichals. These facts may be expressed symbolically thus—IV ax₅, and 3 Ax₄; which symbols come to mean just the same as IV Br-5 and 4 St-4, or as IV Br₅=IV ax, and 4 St₄=3 Ax. Applying this method to the formulæ we get such results as these:—

Thenarocrinus callipygus.

$$I ax_3 \cdot II ax_{(4)} \cdot III ax_{4-10} \cdot IV-VIII ax_{6-18} \cdot f_7,$$

which being interpreted is, Primibrachs 3, Secundibrachs 4 as a rule, Tertibrachs from 4 to 10, Quartibrachs, Quintibrachs, Sextibrachs, Septibrachs, and Octavibrachs from 6 to 18, number of finials uncertain. It also conveys the information that the arms branch eight times, that they are non-pinnulate, and that none of the brachials enter into the dorsal cup.

Botryocrinus pinnulatus.

$$I ax_4 \cdot 2 St-35 +,$$

which indicates that there are four primibrachs, which are free, that there are two arms to each ray, which do not branch again but which bear pinnules, and that the number of ossicles in each of these arms is uncertain, but exceeded 35.

Botryocrinus decadactylus.

$$I ax_{(3-4)} \cdot (II ax_2 \& III Br) \cdot 2 St.$$

The facts expressed by this are somewhat more complicated. Primibrachs are usually 3 or 4, but may be more or less; they are free. It is clear from the symbol 2 St that the arm bifurcates on the primaxil; but the signs in brackets that precede 2 St show that the earlier ossicles of this distichal series do not all bear pinnules, there being first a simple secundibrach, then a secundibrach bearing either a pinnule or armlet, then a simple ossicle which is morphologically a tertibrach, and then the series of pinnuliferous distichals of which the number is uncertain.

Batocrinus Lovei (the formula for all rays except anterior).

$$\overline{\text{I ax}_2 \cdot \text{II ax}_2 \cdot \text{III Br-2} \cdot 4 \text{ St.}}$$

or, more shortly, $\overline{\text{I-III Br}_2} \cdot 4 \text{ St.}$

This is quite clear, the only point to notice being that in the third order of brachials two are fixed, the rest free and pinnuliferous. The corresponding formula for *Batocrinus Christyi* is $\overline{\text{I-III ax}_2} \cdot 8 \text{ St.}$

Gilbertsocrinus tuberculosus.

$$\overline{\text{I ax}_2 \cdot \text{II ax}_3 \cdot \text{III ax}_{4-5}} \cdot 8 \text{ St.}$$

In this case the tertriobrachs are free but bear no pinnules, and there are 8 pinnulate arms to each ray.

One cannot hope to express quite as much in a formula as Mr. Puff got into a shake of Lord Burleigh's head; it is hoped nevertheless that the above examples will show how, by a more rational terminology, with its appropriate symbols, the attempt to apply a system of formulation to Palæozoic Crinoids may have some chance of success. There are of course more complicated plans of arm-branching than those here alluded to; they will demand more complicated formulæ no doubt, but it should be possible to use the same terminology and symbols in all but the most exceptional cases.

Interradial Plates.—Interbrachials.

The term "Interradials" is applied by Wachsmuth and Springer to "all plates interradially disposed in the calyx." These include Basals, Interradials (*s. str.*), Interambulacrals, and Orals. Now, since all these plates are truly *interradial*, and since all morphologists will wish to retain this wide use of the word, it seems a pity to endeavour to restrict it to those interradially situated plates alone that occur in the dorsal cup and that are above the level of the basals. There is a term "Interbrachials," which Wachsmuth and Springer have proposed "for all plates between the rays above the radials," thus, by implication, still further limiting the meaning of Interradials (*s. str.*) to the one plate in each interradius that may occur between the radials themselves. But morphologically these latter plates do not differ from the Interbrachials (W. & Sp.) in the same way as radials differ from brachials; consequently the difference of name is misleading.

Why should not all interradiial plates below the free arms, except of course the basals, be called Interbrachials, each row being distinguished as first, second, third, &c.? Thus the plates to which the term "Interradiial" is now often wrongly restricted would be called "the first Interbrachials," or, when they alone existed in the dorsal cup, simply "the Interbrachials" (*ibr*).

It would be convenient still to distinguish the corresponding plates of the ventral surface as "Interambulacrals" (*iamb*).

Interradiial Plates.—Deltoids.

In the genus *Euspirocrinus* there occur on the oral surface four cordiform or subtriangular plates. One of these is situated in each interradius, except the posterior interradius, and abuts on the upturned portions of the radials, *i. e.* on the radial processes. These four plates meet one another laterally, beneath the ambulacra, except in the posterior interradius. In the posterior interradius there is a larger plate of somewhat similar shape, which has an irregular surface. This plate bears to the peristome the same relation as do the four cordiform plates; it also partly supports the ambulacra; it does not, however, bear the same relation to the radials, as it is separated from them by a varying number of plates connected with the anal tube. One or more of these latter plates, on either side of the anal tube, meet the adjacent cordiform plate beneath the ambulacrum.

The four cordiform plates are also met with in *Gissocrinus*, *Cyathocrinus*, *Carabocrinus*, *Streptocrinus*, and other Inadunate genera. The posterior plate with an irregular surface is usually conspicuous in the same genera. The homologies of these plates with plates occurring in the tegmen of other Crinoids are still in dispute; it is therefore advisable to give to them some names that shall not have too great morphological significance.

The posterior plate appears to have been perforated by one or more pores, being in some cases quite cribriform*, and it is probable that it subserved the functions of a madreporite, whatever those functions may be. It will therefore be convenient to apply to this plate the term "Madreporite," which term, it should be remembered, has no strict morphological significance, since the position of the madreporite in other Echinoderms is by no means constant.

The four cordiform plates have often been regarded as orals,

* Wachsmuth and Springer, "Perisomic Plates," *loc. cit.* p. 358.

a view which in recent times has been advocated by M. Neumayr ('Stämme des Thierreichs'). Most recent writers, however, among whom P. H. Carpenter may be mentioned, have considered them as Interradials, though whether homologous with Interbranchials or with Interambulacrals was left a little uncertain. The most recent and most original view is that of Wachsmuth and Springer*, who treat them as partly, if not altogether, Subambulacrals, a view which can hardly be defended †. The latter authors have, however, suggested that these plates correspond to the deltoids of the Blastoidea (*ibid.*). P. H. Carpenter, in a letter to me, dated 25th September, 1891, said: "They are unquestionably homologous with the deltoids of *Stephanocrinus* and the Blastoids." It is not likely that any one will disagree with this statement, however much opinions may differ as to the homologies of the Blastoid deltoids themselves. Consequently we may temporarily extend to the four cordiform, interradially situated plates of the tegmen, in *Euspirocrinus* and the Cyathocrinidæ, the term "Deltoids," which may be fittingly symbolized by the Greek delta, Δ .

We can hardly doubt that a homologue of the deltoids exists in the posterior interradius; but whether this be represented by the madreporite or by two of the small plates at the base of the anal tube is a question not yet settled. It is therefore inadvisable at present to extend the term deltoid to any plate or plates in the posterior interradius.

Interradial Plates.—Anals x and t.

It may be as well to take this opportunity of stating that the term "anal *x*" will be applied for the present in my papers to the single anal plate that enters into the composition of the dorsal cup in such genera as *Cyathocrinus*, and to the homologue of that plate in other genera. This is the plate for which the term "Brachianal" was proposed in "British Fossil Crinoids," II. p. 330; that term, however, lays too much stress on an inference that has not met with general acceptance.

Once more, however, it is necessary to point out that neither the rejection of the term Brachianal, nor even the rejection of the inference that the anal *x* was primitively derived from a brachial, affect the main contentions of the paper referred to. I still believe, for reasons given in that

* *Op. cit.* pp. 358-360.

† See review of this paper in *Geol. Mag.* dec. iii. vol. viii. p. 222, May 1891.

paper, that the anal x descended into the cup from above; and I believe that the lowest, median, posterior plate of the ventral tube is always this same plate, whether it be right above the radials, as in *Iocrinus* and *Merocrinus*, resting on the radials, as in *Heterocrinus* and *Castocrinus*, between the radials but not in line with them, as in *Homocrinus* and *Dendrocrinus*, in line with the radials, as in *Botryocrinus* and *Cyathocrinus*, or rising above the radials again, as in the later Decadocrinidæ and in the larval *Antedon*. In this view I have the misfortune to differ from Messrs. Wachsmuth and Springer, who apply the term "anal x " to the lowest plate of the tube only when it is partly or entirely within the limits of the dorsal cup. They "apply the term 'anal plate' only to those taking part in the dorsal cup. All others are plates of the anal tube or the ventral sac." That this is not, in *their* opinion, a mere difference of terminology is shown by the arguments that they have based on this supposed difference. If, however, we consider such a form as *Botryocrinus*, we shall see that the anal x is of exactly the same shape and provided with the same axial ridges as the plate that rests immediately on it: there is no visible difference between them, and whatever the one is that we should suppose the other must naturally be. It is merely for convenience, and to distinguish it from the other plates of the cup, that we call one of them "anal x ."

In exactly the same way, the third anal plate that enters to a greater or less extent into the dorsal cup in such genera as *Dendrocrinus*, *Poteriocrinus*, and *Decadocrinus* would appear to be merely the small plate that in *Botryocrinus*, *Cyathocrinus*, and such forms, is seen on the right of anal x , resting partly on it and partly on the right posterior radial, and corresponding to a similar plate on the left. In other words, calling these two plates rt and lt respectively, rt is outside the cup in *Cyathocrinus* but partly inside it in *Poteriocrinus*. Messrs. Wachsmuth and Springer, however, in their paper on the Perisomic Plates (p. 385) have advanced the view, apparently for the first time, that in the *Poteriocrinites* "a new plate was introduced beneath the other, a sort of third anal." That is to say, in their opinion the third anal of *Poteriocrinus* is a fresh development without any homologue in the *Cyathocrinidæ* and *Botryocrinites*. But surely the constancy in shape and position of the anal cup-plates x and rt is hardly consistent with the idea that they are merely supplementary plates developed to suit the needs of those particular genera in which they appear. It seems more in accordance with the principles that have hitherto governed

Crinoid morphology to regard their resemblances as due to homogeneity rather than to homoplasy.

Imperforate Articulation.

Reference to "British Fossil Crinoids," II. p. 314, will show that there is some difficulty in distinguishing between those forms of joint that are there called "Loose suture" and "Muscular articulation." There are among Inadunate Crinoids many instances of arm-joints in which there is a well-defined fuleral ridge, combined with muscular and ligamental depressions, but in which the axial canal does not happen to be separated from the ventral groove by stereom and so does not perforate the fuleral ridge. It might be advisable to distinguish these joints as "Imperforate articulation," and to call the muscular articulation in which "the articular ridge, whether vertical or transverse, is always perforate," "Perforate articulation."

It is unfortunately necessary to explain that the word "joint" is used here and throughout my papers in its ordinary English and anatomical sense, and not in that restricted and different sense which is usually ascribed to it by crinoidologists and cooks.

VIII.—*On the Oviposition and Embryonic Development of the Crocodile.* By Dr. A. VOELTZKOW, of Majunga, Madagascar*.

THE Madagascar Crocodile, *Crocodilus niloticus*, Laur. (*madagascariensis*, Grandid.), is not only one of the commonest reptiles, but perhaps the commonest Vertebrate of the island. It is found in large numbers wherever there is water, in every pool and stream. The natives distinguish two species, one (*Cr. niloticus*) with a longer, and another with a shorter head and greater length of body; the latter is said to occur only in the large rivers in the primeval forest, and the natives are extraordinarily afraid of it, as it is stated to be very savage; it is probably identical with *Cr. robustus*, Vaill., Grandid. I

* Translated from the 'Mathematische und Naturwissenschaftliche Mitteilungen aus den Sitzungsberichten der Königlich Preussischen Akademie der Wissenschaften zu Berlin,' Heft ii., 1891, pp. [115] 51-56 [120].